

PASTORAL PRACTICES, WILD MAMMALS AND CONSERVATION STATUS
OF ALPINE MEADOWS IN WESTERN HIMALAYA¹G.S. RAWAT²¹Accepted December 07, 2006²Wildlife Institute of India, Chandrabani, Dehradun 248 001, Uttarakhand, India. Email: rawatg@wii.gov.in

An ecological expedition was conducted across the alpine region of western Himalaya, from June to October 2004, to assess the conservation status of alpine meadows, current land use practices, patterns of plant species diversity and wildlife use. This paper deals with the findings pertaining to pastoral practices, abundance of wild mammals and status of alpine meadows under varying intensity of livestock grazing. Barring 3-4 protected areas (PAs), most of the alpine meadows were heavily grazed during summer. Abundance of wild mammals was very low in heavily grazed and degraded PAs. Unless management authorities rationalize livestock grazing, in consultation with the local communities, several PAs would fail to meet conservation objectives, and alpine meadows would further degrade, leading to environmental disaster in the region.

Key words: alpine meadows, ecological expedition, habitat degradation, livestock grazing, pastoral practices, western Himalaya, wild mammals

INTRODUCTION

The alpine zone occupies nearly 33% of the geographical area in the Himalayan region and represents one of the most fascinating biomes, well known for its biological, geo-hydrological, aesthetic and cultural values. This zone is separated by a distinct treeline towards lower elevation that lies around 3300 ± 200 m above msl in the western Himalaya, and 3800 ± 200 m above msl in the eastern Himalaya. Diversity of life forms, structure and species composition of alpine vegetation has always attracted a large number of naturalists, phyto-geographers and ecologists (e.g., Mani 1974; Rau 1975). The most striking feature of the alpine vegetation is an abundance of herbaceous plants along narrow climatic gradients exhibiting interesting patterns of adaptations to harsh environments, short growing season and relatively recent Palaeo-history (Korner 1999; Vishnu-Mittre 1984). Though highly fragile and dynamic, the alpine habitats not only support diverse groups of fauna, but also form the upper catchments of the Himalayan rivers that serve as lifeline for millions of people along their lower basins. Hence, the health and integrity of the alpine ecosystems has direct bearing on the life-support system, environmental stability, biodiversity and human welfare in the region.

The alpine meadows of western Himalaya have been used for livestock grazing by a large number of agro-pastoral communities for several centuries (Tucker 1986). Other human activities in the alpine areas include extraction of wild medicinal plants for local as well as commercial use, pilgrimage, recreation such as trekking, camping and skiing. Broadly, there are two categories of meadows in the alpine zone of

Himalaya: (i) alpine moist meadows on the south facing slopes of Greater Himalaya dominated by herbaceous formations, locally termed as *Bugyal* in Uttarakhand, *Kanda* in Himachal Pradesh and *Marg* in Jammu and Kashmir, (ii) alpine dry pastures located in the rain shadow zone or trans-Himalayan zone characterized by dry scrub and desert steppe dominated by graminoids (Rawat and Adhikari 2005). The two regions differ considerably in terms of plant community composition, primary productivity and history of grazing by domestic and wild ungulates (Mishra 2001; Bagchi *et al.* 2004). Although the alpine meadows play an important role in relieving the grazing pressure on the forests and the grazing land of the lower altitudes, increased livestock and overuse has led to degradation of alpine habitats (Rawat 1998). Several ecologists have pointed out that the alpine meadows in many parts of the Greater Himalaya have been overused and degraded (Negi *et al.* 1993; Sundriyal 1989; Shah 1988). It has also been established that extensive grazing by migratory livestock negatively affects the habitat and abundance of ungulates (Sathyakumar *et al.* 1993; Bhatnagar *et al.* 2000; Vinod and Sathyakumar 2005). Nevertheless, livestock grazing in the alpine areas of the Himalaya is likely to continue as major land use for a long time, in the absence of better livelihood options for local communities. Depending on changing socio-economic conditions of the local people, livestock composition and grazing pressures have changed in many areas. This calls for a landscape level assessment of grazing pressure, wildlife abundance and status of meadows.

This paper deals with the pastoral practices, livestock densities and abundance of wild mammals across the alpine landscape in western Himalaya based on a recent ecological

expedition. Conservation status of the alpine meadows under varying intensity of livestock grazing has been discussed. The major objectives of the expedition were to (i) study the patterns of plant species diversity across environmental gradients, (ii) quantify the availability of wild medicinal and aromatic plants (MAPs) in the alpine region, (iii) assess the ecological condition of the alpine habitats *vis-a-vis* current land use practices, and (iv) document the wildlife use of alpine meadows along the survey route. The results of the expedition for the state of Uttaranchal (now Uttarakhand) are given in Rawat (2005).

STUDY AREA AND METHODS

An ecological expedition across the alpine region of western Himalaya was conducted from June to October 2004 covering the states of Uttarakhand, Himachal Pradesh and Jammu and Kashmir. Over 2500 km was traversed on foot covering an altitudinal zone of 3300-5500 m above msl on either side of the Greater Himalaya. The starting point of the expedition was near the Indo-Nepal border in Uttarakhand (30° 06' 31.7" N and 80° 50' 04.7" E), ending near Amarnath in Kashmir Himalaya (34° 12' 49.4" N and 75° 27' 48.8" E). A large number of forest officials and field staff of State Forest Departments joined the expedition at various places, in addition to a few volunteers. The expedition route covered a number of wildlife sanctuaries (WLSs), national parks (NPs), community owned forests or grazing lands (*Van Panchayat*), reserved forests (RFs) and unclassified state forests (USFs). On an average, a distance of 15-20 km was traversed in a day. Over 300 sites were sampled for 10 x 1 sq. m random quadrants for the analysis of species diversity following Rawat *et al.* (2001). The landscape level survey allowed an assessment of a wide range of vegetation formations and habitats, such as glaciated valleys, plateaus, moraines, high passes, scree slopes, glacial outwash, avalanche traps, stream courses and stable slopes. Environmental parameters, such as soil depth, soil texture, altitude and aspect, were noted and geographical co-ordinates at each sample point were recorded using Global Positioning System (GPS), to be analysed in detail at a later date. The major PAs visited during the survey include Askot WLS, Nanda Devi Biosphere Reserve, Valley of Flowers NP, Kedarnath WLS, Gangotri NP, Govind WLS, Churdhar WLS, Raksham Chitkul WLS, Rupi-Bhaba WLS, Seichu-Tuan WLS, Rungdum WLS and Thajwas WLS. The route followed during the survey is shown in Fig 1.

Information on the pastoral practices and number of livestock (species wise) was collected along the survey route through informal interviews with the herders and local forest officials. Legal and management status of the land in Biosphere

Reserves (BRs), NPs, WLSs, *Van Panchayat*, RFs, USFs were obtained from forest / revenue records. Information was also collected on the approximate area of the meadows, dominant vegetation types, intensity of human use and number of livestock and duration of grazing. Direct and indirect evidence of wild mammals were recorded along the survey route on a daily basis, aided by previous experience, local informants and available literature (Prater 1980; Menon 2003).

Conservation status of alpine meadows / vegetation was assessed along the survey route. From the herders' point of view, good pastures are characterized by dominance of palatable forbs, absence of weedy and unpalatable species, and an extensive area that could support larger herds. Ecologically, sites with better conservation status are those which represent the full range of alpine habitats (and microhabitats), without human induced soil erosion. About 162 meadows were rapidly assessed in terms of stages of degradation and one of the following categories was assigned to each: (a) Pristine meadows (climatic climax with least soil erosion caused due to anthropogenic activities), (b) Slightly degraded or intact meadows, (c) Moderately degraded meadows (gently undulating areas with short duration of grazing only by sheep and goats) (d) Heavily degraded areas characterized by heavy soil erosion and infested by spiny herbs (*Cirsium falconeri*, *C. verutum* and *Morina longifolia*), and unpalatable herbs (*Rumex nepalensis*, *Phlomis bracteosa*, *Hackelia uncinata* and *Osmunda claytoniana*), among others. These criteria are not applicable for assessment of alpine vegetation in the trans-Himalaya or closer to high alpine pioneer vegetation.

RESULTS AND DISCUSSION

Pastoral Practices

Five distinct pastoral practices are prevalent across the alpine landscape in the western Himalaya: nomadic, semi-nomadic, nuclear transhumance, trans-migratory and sedentary (resident). True nomadic pastoralism is practiced mainly by the *changpa* herders in the Changthang plateau of Ladakh, which lies outside the limits of current survey. The *gujjars* (the buffalo herders in the southern slopes of the Greater Himalaya and the Shivaliks) have over the years shifted from nomadic to semi-nomadic lifestyle. The *gaddis* and *bakarwals* of Himachal Pradesh and Jammu & Kashmir follow semi-nomadic lifestyle (only few members of a family move long distance with their livestock). Many agro-pastoral communities in Uttarakhand and Himachal Pradesh practice nuclear transhumance (a part of the family moves to higher altitudes closer to treeline along with surplus cattle). Trans-migration (seasonal altitudinal movement by the entire family

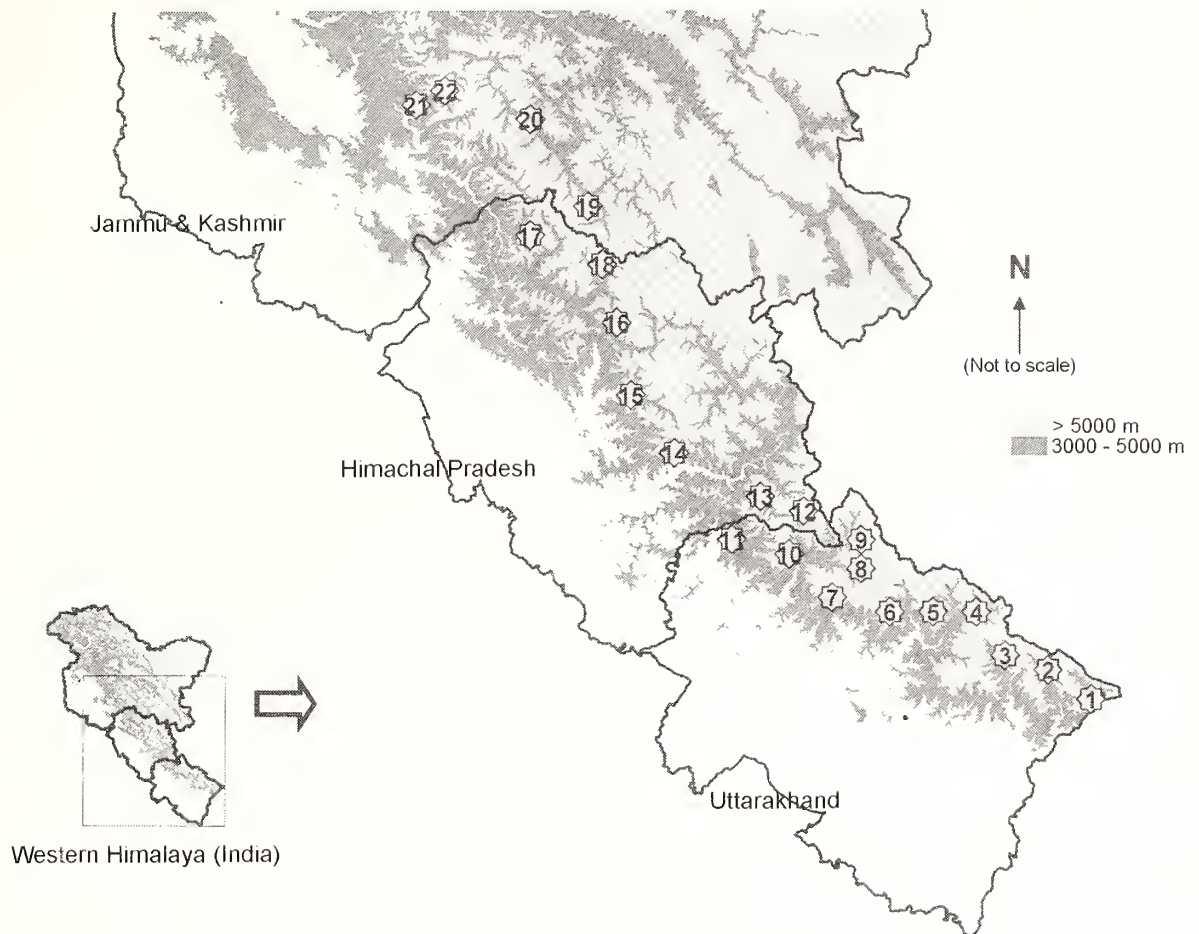


Fig 1: Route followed and localities covered during the alpine expedition (2004)

- 1 = Byans Valley, 2 = Darma & Askot WLS, 3 = Johar Valley, 4 = North of Nanda Devi BR, 5 = Valley of Flowers NP, 6 = Kedarnath WLS, 7 = Khatling, 8 = Gangotri NP, 9 = Nilang Valley, 10 = Gidara, 11 = Govind WLS, 12 = Raksham Chitkul WLS, 13 = Sangla Valley, 14 = Rupi-Bhaba WLS, 15 = Bhrigu lake & Rohtang, 16 = Paton Valley, Lahul, 17 = Pangi, 18 = Myar Valley, 19 = Padam, Zanskar, 20 = Surru valley, 21 = Thajwas WLS, 22 = Amarnath

along with the livestock) is practiced mainly by the *bhotiya* communities in various parts of Uttarakhand, such as Byans, Darma, Johar and the upper basins of Alaknanda and Bhagirathi. Presently only 20-30% of the original households and only few members in each family along with most of the livestock, except milch cattle, migrate to the distant alpine valleys, in the process making available several alpine pastures for other communities belonging to the lower parts of the state (Uttarakhand) and the *gaddi* herders from Himachal Pradesh. In the high altitude villages of Kinnaur, Spiti, Lahul, Pangi and Zanskar there is round the year grazing by the resident livestock, in addition to migratory livestock. In Chamoli, Tehri, Uttarkashi and Kinnaur districts, several families drive their scrub cattle to sub-alpine and alpine areas for free grazing during the snow free period (June-October). This practice leads to faster degradation of meadows and will

need immediate reversal if conservation has to succeed in and around the nearby PAs.

Densities of livestock in the alpine meadows of three states have been compared in Table 1. The survey revealed that livestock densities in the alpine areas of Uttarakhand (33.92 ± 10.01 /sq. km) were much higher compared to Himachal Pradesh (17.55 ± 9.25 /sq. km) and Jammu & Kashmir (10.45 ± 12.33 /sq. km). It is to be noted that the herders from Chamba, Kangra and other parts of Himachal Pradesh take their sheep and goats either towards the Sarchu plains in Jammu and Kashmir or to the alpine valleys of Uttarakhand, which is ascribed to degradation of alpine pastures and shortage of forage in the state (personal interviews with the herders). Highest densities of sheep and goats were observed in the alpine areas of Govind WLS (50 sheep and goats, and 10 bovinds and equids per sq. km) followed by Thajwas WLS

Table 1: Density of livestock in alpine meadows of Western Himalaya

Parameters	Uttarakhand	Himachal Pradesh	Jammu & Kashmir
Geographical Area (sq. km)	53,485	55,670	222,240
Area under Alpine Vegetation (sq. km)**	8,524	17,296	131,851
Density of sheep & goats in alpine areas (no. / sq. km)	33.92 ± 2.65	17.55 ± 9.25	10.45 ± 12.33
Density of bovids & equids in alpine areas* (no. / sq. km)	2.48 ± 2.65	1.62 ± 2.46	1.42 ± 1.27

(Source: *State Animal Husbandry Departments, **Lal *et al.* 1991)

(31 sheep and goats, and 20 mules per sq. km) and Rupini-Bhaba WLS (23 sheep and goats, and 3-4 bovids per sq. km). Except core areas of Nanda Devi NP, Valley of Flowers NP and part of Gangotri NP, all PAs had high grazing pressure (mean density of sheep and goats 28.23 ± 17.90 /sq. km, and bovids and equids 2.15 ± 2.87 /sq. km). Interestingly, mean livestock densities during peak summer months outside the PAs (22.21 ± 19.16 sheep and goats /sq. km and 1.97 ± 1.81 bovids and equids /sq. km) were lower compared to densities within PAs, though the differences are not significant (Table 2).

Abundance of wild mammals

Of about 51 species of wild mammals reported from the alpine region of western Himalaya (Menon 2003), only 25 were seen or recorded along the survey route. The 16 species sighted were Himalayan Tahr (*Hemitragus jeulalicus*), Himalayan Musk Deer (*Moschus chrysogaster*), Blue Sheep (*Pseudois nayaur*), Goral (*Neuorhaedus goral*), Asiatic Black Bear (*Selearctos thibetanus*), Himalayan Yellow-throated Marten (*Martes flavigula*), Red Fox (*Vulpes vulpes*), Himalayan Marmot (*Marmota himalayana*), Long-tailed Marmot (*Marmota caudata*), Himalayan Weasel (*Mustela sibirica*), Himalayan Palm Civet (*Paguma larvata*), Tibetan Woolly Hare (*Lepus oiostolus*), Royle's Pika (*Ochotoua roylei*), Large-eared Pika (*O. macrotis*), Mountain Vole (*Alticola argentatus*) and Lesser Bat (*Hipposideros* sp?), while the other 8 species, namely Hangul (*Cervus elaphus hanglu*), Serow (*Nemorhaedus sumatraensis*), Himalayan Brown Bear (*Ursus arctos*), Tibetan Wolf (*Canis lupus chawco*), Snow Leopard (*Uncia uncia*), Himalayan Stoat or Ermine (*Mustela erminea*), Tibetan Wild Ass (*Equus kyang*) and Golden Jackal *Canis aureus*) were confirmed based on indirect evidence such as skin, horns, skull, tracks, droppings and reliable local informants. One of the significant findings of this survey is the direct and indirect evidence of a few trans-Himalayan mammals (Woolly Hare and Tibetan Wild Ass) along the northern fringes of Uttarakhand. There is no report of these species from Uttarakhand in published literature. In Nilang Valley (part of Gangotri NP) local people reported presence of Tibetan Argali or Nayan (*Ovis amnou*

hodgsoni) and Wild Yak (*Bos grunniens* locally known as 'doug'). Further status surveys would be required to confirm their presence in the interior areas of this Park. It is also to be noted that inner drier ranges of Uttarakhand exhibit characteristics of trans-Himalaya rather than Greater Himalaya. This calls for a slight modification of current biogeographic classification suggested by Rodgers and Panwar (1988).

Highest abundance of wild ungulates was found en route to Gangotri glacier (part of Gangotri NP). In a walk of 13 km, 65 Blue Sheep in four groups were sighted. This valley (c. 250 sq. km) has been protected from livestock grazing since the last decade and according to a recent survey, it supports a population of 270-300 Blue Sheep (Wildlife Warden, Gangotri NP, pers. comm.). Estimates for Himalayan Musk Deer and other mammals are not available from this valley. Upper catchments of Girthi Ganga (part of Nanda Devi BR in Uttarakhand) also showed higher abundance of Blue Sheep, Himalayan Marmot and Snow Leopard compared to all other sectors along the survey route. The shepherds reported frequent killings of domestic sheep and goats by Snow Leopard in this area. A major portion of this landscape represents alpine arid pasture (steppe vegetation), which is contiguous with the Tibetan plateau. Livestock grazing in this valley is carried out only for a short period (July-August). Other PAs west of Govind WLS had a much lower abundance

Table 2: A comparison of livestock densities within PAs and outside PAs within alpine region of Western Himalaya*

Parameters	Inside PAs (N = 14)	Outside PAs (N = 13)
Approximate area surveyed (sq. km)	3205.00	3685.00
Density of sheep & goats ± SD (no. / sq. km)	28.23 ± 17.90	22.21 ± 19.16
Density of bovids & equids ± SD (no. / sq. km)	2.15 ± 2.87	2.06 ± 2.38

*Note: Independent samples test: No SD in the densities of sheep and goats (t=0.842; df=24.487, 95% confidence interval) and bovids and equids (t=0.200; df=22.130, 95% confidence interval)

of wild mammals. According to forest officials, livestock killing by Brown Bear in Govind WLS has been a major cause of concern. The alpine areas of Seichu Tuan WLS in Pangi support small populations of Himalayan Tahr, Himalayan Ibex, Brown Bear and Himalayan Musk Deer. Official estimates of Ibex and Himalayan Tahr in this sanctuary are 250-300 and 50-60 respectively, but there is also a heavy influx of livestock (>2500 sheep and goats) during summer. Raksham-Chiktul, Churdhar and Thajwas sanctuaries exhibited the least abundance of wild mammals. Incidentally, Churdhar and Thajwas sanctuaries are <100 sq. km in size and have very high livestock densities.

The alpine areas outside the current PA network also varied considerably in terms of wildlife abundance. As expected, interior localities free from human habitation and low grazing pressure had higher abundance of wild mammals. However, such areas are vulnerable to poaching, unless regulated by the local communities themselves. A hill slope opposite Niti village in Uttarakhand (buffer zone of Nanda Devi BR) has been protected by the villagers from livestock grazing for the last 8-10 years, mainly for fodder and medicinal herbs. This slope offers excellent sub-alpine and alpine habitats. In a walk of about 2 km, 12 piles of Himalayan Musk Deer pellets were encountered on this slope. It was also interesting to find three active colonies of the Himalayan Marmot in the same area. Occurrence of the Himalayan Musk Deer and the Himalayan Marmot in the same habitat has not been reported from other parts of the Himalaya. Other examples of community regulated resource use and restriction on poaching were seen in Johar valley (Uttarakhand), Upper Sural valley in Pangi sub-division (Himachal Pradesh) and Rungdum area of Surru Valley (Jammu and Kashmir). Excessive grazing and rush for high value MAPs, such as the Palm Orchid (*Dactylorhiza hatagirea*) and Caterpillar Mushroom (*Cordyceps sinensis*) by local communities in the Greater Himalaya of Uttarakhand are the major factors affecting wild mammals during summer. In Byans Valley (eastern Uttarakhand) local people reported recovery of wild ungulates during the past 8-10 years due to stringent laws, conservation awareness and a drastic reduction in trans-migration. The scenario is, however, different in interior parts of Lahul where grazing pressure has increased over the years. A four day walk (c. 80 km) along Myar valley (Lahul) yielded no direct sightings of mammals and only few indirect evidences of Blue Sheep, Ibex and Red Fox.

Status of the meadows

Based on general appearance and species composition, the moist meadows can be grouped into the following six categories (i) Tall herbaceous formations, (ii) Short forbs, (iii)

Matted shrubs / shrubberies, (iv) *Danthonia* grasslands, (v) *Kobresia* meadows, and (vi) Cushionoid vegetation. Characteristic features of these meadows are described by Rawat (2005). Vegetation cover and number of species per unit area were the highest in tall and short herbaceous meadows, especially in the high rainfall zones of Greater Himalaya (cover >90% and species richness 35-45 per site). *Kobresia* meadows are generally considered climax formations on the south facing high alpine (>4000 m above msl) slopes. Of the 162 random sites assessed for stages of degradation within the moist meadows of the Greater Himalaya, only 6 sites (3.7%) were classified as 'pristine meadows'. Intact (slightly degraded), moderately degraded and heavily degraded sites constituted 18.5, 39 and 30.8% respectively. Thirteen sites (8%) showed signs of recovery from heavily degraded stages to moderate stage. The meadows grazed by heavier livestock (especially buffaloes, cattle and equids) for a longer period were the most degraded.

Conservation status of alpine meadows was best within a few PAs, namely Valley of Flowers NP, parts of Nanda Devi BR, Kedarnath WLS, and interiors of Tehri-Uttarkashi districts in Uttarakhand. The sub-alpine slopes of Thajwas WLS and Amarnath were dominated by a least preferred, unpalatable grass *Stipa sibirica*. Some of the heavily degraded alpine sites included Dayara, Auli, Panwali Kantha, Kedarkantha in Uttarakhand, Churdhar, Sangla Valley, Rohtang-Bhrigu Tal, Rupi Bhaba WLS in Himachal Pradesh, and Amarnath, Thajwas areas in Kashmir. The alpine slopes in Sangla Valley and many parts of Lahul are vulnerable to encroachment, especially for cultivation of cash crops, such as Green Pea (*Pisum sativum*). Within the Zanskar range, conservation status of pastures was best along the left bank of Surru river, especially from Rangdum to Nun Kun base. These slopes were reported to have moderate livestock grazing and support a reasonably good population of Blue Sheep. Thajwas WLS is grazed by more than 2500 sheep and goats and over 200 ponies during summer (June-September). According to the wildlife authorities, upper reaches of Thajwas support a small population of Hangul (Kashmir Stag), Himalayan Musk Deer and Asiatic Black Bear. The Sanctuary is contiguous with upper parts of Dachigam NP. The alpine slopes on way to Amarnath are frequently broken due to avalanches and landslips. The estimated area of alpine meadows in the vicinity of Amarnath is about 250 sq. km and over 3000 sheep and goats and 100 mules graze on the alpine slopes. In addition, every year the Amarnath area is visited by over two lakh pilgrims. Trampling of the alpine vegetation, overgrazing by pack animals and littering the trail with non-biodegradable waste have led to severe degradation of this alpine habitat.

CONCLUSION

Landscape level survey of the alpine zone in the western Himalaya revealed several facets of pastoral practices, distribution and abundance of wild mammals and conservation issues. Livestock density in the alpine areas of Uttarakhand was higher compared to those of Himachal Pradesh and Jammu and Kashmir. There were no significant differences in the livestock densities within and outside the PAs, barring a few PAs in Uttarakhand. Influx of large herds from Himachal Pradesh to the alpine areas of Uttarakhand during the recent decades, and increase in the population of heavy livestock, especially around treeline are causes for concern and need to be addressed urgently.

Low abundance of wildlife in most of the areas can be attributed to habitat degradation and loss due to excessive grazing by migratory and resident livestock. Larger PAs and remote valleys allow adequate spatio-temporal separation among domestic livestock and wild ungulates. Such areas had higher abundance of wild mammals and better conservation status of meadows, provided there was low pressure from tourism and pilgrimage. Based on the habitat characteristics and evidences of trans-Himalayan mammals (direct and indirect), it is recommended that northern parts of Uttarakhand be included under Biogeographic zone IB (Trans-Himalaya) by making appropriate amendments in the current biogeographic classification by Rodgers and Panwar (1988).

A large number of meadows (31% of the survey localities) were heavily degraded due to extensive grazing by livestock. 39% of the meadows were moderately degraded and only a

few (8%) sites represent pristine meadows. Quantitative information on the extent of degradation within and outside various PAs would be necessary in order to monitor the condition of meadows or formulate recovery plans. Management authorities need to rationalize livestock grazing within high altitude PAs in order to pursue conservation objectives and check further degradation of the alpine meadows in the Himalaya.

ACKNOWLEDGEMENTS

The alpine expedition was sponsored by the Herbal Research and Development Institute (HRDI), Gopeshwar. I am grateful to the following officials of the Uttarakhand Government for facilitating the survey: Dr. R.S. Tolia, Ex-Chief Secretary, Mrs. Vibha Puri Das, Principal Secretary, Shri S. Chandola, Chief Wildlife Warden, Uttarakhand, Shri S.K. Singh, Director, HRDI and Prof. A.N. Purohit, M.L. Bharatiya Chair at HRDI.

I thank all the members of the expedition, especially Mr. Gajendra Singh, Mr. Manoj Chandran, Mr. K.S. Rawat, and Dr. G.S. Goraya for their wonderful company. Thanks are also due to the Chief Wildlife Warden, Himachal Pradesh and the Chief Wildlife Warden, Jammu and Kashmir, various officials of the Indian Army and Indo-Tibetan Border Police for their unconditional support during the survey in remote localities. Shri P.R. Sinha, Director and other colleagues from Wildlife Institute of India, namely Drs. B.S. Adhikari, K. Ramesh and Manoj Agarwal are thanked for their encouragement and help.

REFERENCES

- BAGCHI, S., C. MISHRA & Y.V. BHATNAGAR (2004): Conflicts between traditional pastoralism and conservation of Himalayan Ibex (*Capra ibex sibirica*) in the Trans-Himalayan mountains. *Anim. Conserv.* 7: 121-128.
- BHATNAGAR, Y.V., G.S. RAWAT, A.J.T. JOHNSINGH & M. STUWE (2000): Ecological separation between Ibex and resident livestock in a Trans-Himalayan protected area. Pp. 70-83. *In: Grassland Ecology and Management in Protected Areas of Nepal* (Eds: Richard C., K. Basnet, J.P. Sah & Y. Raut). International Centre for Integrated Mountain Development, Kathmandu, Nepal.
- KORNER, C. (1999): *Alpine Plant Life*. Springer-Verlag, Berlin.
- MANI, M.S. (1974): *Ecology and Biogeography in India*. W. Junk Publishers, The Hague, The Netherlands.
- MENON, V. (2003): *A Field Guide to Indian Mammals*. Penguin Book India (P) Ltd. & Dorling Kindersley, New Delhi.
- MISHRA, C. (2001): *High altitude survival. Conflicts between pastoralism and wildlife in the Trans-Himalaya*. Doctoral Thesis, Wageningen University, The Netherlands.
- NEGI, G.C.S., H.C. RIKHARI, J. RAM & S.P. SINGH (1993): Foraging niche characteristics of horses, sheep and goats in an alpine meadow of the Indian Central Himalaya. *J. Applied Ecology* 30: 383-394.
- PRATER, S.H. (1980): *The Book of Indian Animals*. Bombay Natural History Society. Reprint.
- RAWAT, G.S. (1998): Temperate and Alpine Grasslands of the Himalaya: Ecology and Conservation. *Parks* 8(3): 27-36.
- RAWAT, G.S. (2005): *Alpine Meadows of Uttaranchal: Ecology, land use practices and status of medicinal and aromatic plants*. Bishen Singh Mahendra Pal Singh, Dehradun.
- RAWAT, G.S. & B.S. ADHIKARI (2005): Millennia of grazing history in eastern Ladakh, India, reflected in rangeland vegetation. Pp: 199-210. *In: Land Use Change and Mountain Biodiversity* (Eds: Spehn, E.M., M. Liberman & Ch. Korner). CRC Press, NY, USA.
- RAWAT, G.S., B.S. ADHIKARI, & B.S. RANA (2001): *Vegetation surveys in the Indian Trans-Himalaya*. Pp. 7-14. *In: Conserving Biodiversity in the Trans-Himalaya: New Initiatives of Field Conservation in Ladakh* (Ed: Anon.). Wildlife Institute of India, Dehradun.
- RAU, M.A. (1975): *High Altitude Flowering Plants of West Himalaya*. Botanical Survey of India, Howrah, India.
- RODGERS, W.A. & H.S. PANWAR (1988): *Planning a wildlife protected area network in India*. Vol. I & II. A report prepared for the Department of Environment, Forests and Wildlife, Government of India. Wildlife Institute of India, Dehradun.

- SATHYAKUMAR, S., S.N. PRASAD, G.S. RAWAT & A.J.T. JOHNSINGH (1993): Conservation status of Himalayan Musk Deer and livestock impacts in Kedarnath Wildlife Sanctuary, Western Himalaya. Pp: 240-245. *In: High Altitudes of the Himalaya* (Eds: Pangtey, Y.P.S & R.S. Rawal). Gyanodaya Prakashan, Nainital.
- SHAH, M.H. (1988): Role of nomads in the destruction of alpine and subalpine pastures and future strategies. Pp. 148-152. *In: Rangelands: resource and management* (Eds: Singh, P. & P.S. Pathak). Range Management Society of India, Jhansi, India.
- SUNDRIYAL, R.C. (1989): Assessment of the grazing ability of an alpine pasture in the Garhwal Himalaya, India. *Environ. Ecol.* 7(1): 247-249.
- TUCKER, R.P. (1986): The evolution of transhumant grazing in the Punjab Himalaya. *Mountain Res. & Dev.* 6(1): 17-28.
- VINOD, T.R. & S. SATHYAKUMAR (2005): Conservation status of mountain ungulates in Great Himalayan National Park, Himachal Pradesh. Pp. 35-39. *In: Wildlife Conservation, Research and Management* (Eds: Jhala, Y.V., R. Chellam & Q. Qureshi). Wildlife Institute of India, Dehradun.
- VISHNU-MITTRE (1984): Floristic changes in the Himalaya (southern slopes) and Siwaliks from Mid-Tertiary to Recent times. Pp. 483-503. *In: The evolution of the east Asian Environment*. Vol. II. (Ed: Whyte, R.O.). Centre of Asian Studies, University of Hongkong Press.

